CLAIMS

What is claimed is:

1. An optical device comprising a waveguide structure formed by a thin strip of material having a relatively high free charge carrier density surrounded by material having a relatively low free charge carrier density, the strip having finite width and thickness with dimensions such that optical radiation having a free space wavelength in the range from about 0.8μm to about 2μm couples to the strip and propagates along the length of the strip as a plasmon-polariton wave.

2. A device according to claim 1, wherein the strip is straight, curved, bent, or tapered.

3. A device according to claim 1, further comprising at least a second said waveguide structure similar to the first-mentioned waveguide structure, the second waveguide structure comprising a second said strip having one end coupled to the first-mentioned strip, wherein the first-mentioned strip is curved and the second strip is offset outwardly relative to an axis of curvature of the first-mentioned strip.

4. A device according to claim 3, wherein the second strip is curved oppositely to the first strip such that the first and second strips form an S-bend.

5. A device according to claim 4, further comprising third and fourth said waveguide structures comprising third and fourth strips, respectively, the third strip having one end coupled to an end of the first strip opposite that connected to the second strip and the fourth strip having one end coupled to an end of the second strip opposite that connected to the first strip, the third and fourth strips each being offset outwardly relative to an axis of curvature of the strip to which it is coupled.

6. A device according to claim 1, further comprising at least two additional said waveguide structures comprising second and third strips, respectively, the second strip for inputting said radiation to one end of said first-mentioned strip and the third strip for receiving said radiation from the opposite end of said first-mentioned strip, wherein the first-mentioned strip is curved and said second and third strips are each offset outwardly relative to an axis of curvature of the first-mentioned strip.

7. A device according to claim 1, further comprising at least second and third waveguide structures both similar in construction to the first-mentioned waveguide

structure and having second and third strips, respectively, the second and third strips having respective ends coupled in common to one end of the strip of the first-mentioned waveguide structure to form respective arms of a combiner/splitter, the arrangement being such that said optical radiation leaving said first-mentioned strip via said one end will be split between said second and third strips and conversely said optical radiation coupled to said one end by said second and third strips will be combined to leave said first-mentioned strip by an opposite end.

8. A device according to claim 7, further comprising a transition waveguide structure coupling the second and third strips to the first-mentioned strip, the transition waveguide structure being similar in construction to the first-mentioned waveguide structure and comprising a strip having a narrower end coupled to the first-mentioned strip and a wider end, the second and third strips being coupled together to the wider end.

9. A device according to claim 8, wherein the second and third strips each comprise an S-bend, and the S-bends diverge away from the wider end of the transition strip.

10. A device according to claim 1, further comprising a bifurcated transition section (106') having a narrower end portion (115A) coupled to the first-mentioned waveguide structure and two curved sections (115B, 115C) diverging away from the narrower end portion 115A to form respective arms of a combiner/splitter, such that light entering the narrower end portion will emerge from respective distal ends of the curved sections 115B and 115C.

11. A device according to claim 10, further comprising two additional bend sections (108) connected to distal ends of the curved sections (115B, 115C), respectively, to form with the transition section two mirrored and overlapping S-bends.

12. A device according to any one of claims 7 to 11, further comprising a second combiner/splitter similar in construction to the first combiner/splitter and connected to the first combiner/splitter to form a Mach-Zender interferometer, each arm of the first combiner/splitter being connected to a respective one of the arms of the second combiner/splitter to form a corresponding interferometer arm, the arrangement being such that optical radiation input via said first strip of the first combiner/splitter produces two plasmon-polariton wave portions which propagate along, respectively,

arms of the Mach-Zender interferometer and are recombined by the second combiner/splitter.

13. A device according to claim 12, wherein each arm of the first combiner/splitter is connected to a respective arm of the second combiner/splitter by a respective intermediate section of waveguide structure similar in construction to the first waveguide structure, and the device further comprises means for adjusting the characteristics of one of said intermediate sections relative to those of the other intermediate section and thereby propagation characteristics of the corresponding one of said two plasmon-polariton wave portions so as to obtain destructive interference upon recombination and thereby modulate the intensity of said optical radiation.

14. A device according to claim 13, wherein the material surrounding the strip of the waveguide structure whose characteristics are adjusted is electro-optic, and the adjusting means establishes an electric field in said electro-optic material and varies said electric field so as to vary the refractive index of the electro-optic material.

15. A device according to claim 14, wherein the adjusting means comprises a pair of electrodes spaced apart with the strip between them and a voltage source connected to the electrodes for applying a voltage between the electrodes so as to establish said electric field in said electro-optical material.

16. A device according to claim 14, wherein the adjusting means comprises at least one electrode adjacent the strip of the waveguide structure whose characteristics are adjusted and a voltage source for applying said voltage between the electrode and said strip so as to establish said electric field in said material therebetween.

17. A device according to claim 14, wherein the adjusting means comprises a pair of electrodes spaced apart with said strip therebetween and a voltage source connected between said strip and both electrodes, in common, for applying a voltage between the electrodes and the strip to establish said electric field in said electro-optic material.

18. A device according to claim 13, wherein the adjusting means is arranged to induce a magnetic field in said at least one of the parallel branches.

19. A device according to claim 13, wherein the adjusting means modulates the intensity of said optical radiation substantially to extinction.

20. A device according to claim 1, further comprising at least two additional waveguide structures, the at least three waveguide structures arranged to form an intersection, respective strips of the at least three waveguide structures each having one end connected to juxtaposed ends of the other strips to form said intersection, distal ends of the at least three strips constituting ports such that optical radiation input via the distal end of one of the strips will be conveyed across the intersection to emerge from at least one of the other strips.

21. A device according to any one of claims 3 to 20, wherein said strips are integral with each other.

22. A device according to claim 1, further comprising at least a second waveguide structure similar in construction to the first-mentioned waveguide structure, the first and second waveguide structures being arranged to form a coupler, first and second strips of the first and second waveguide structures, respectively, extending parallel to each other and in close proximity such that propagation of said optical radiation is supported by both strips, the device further comprising input means for inputting said optical radiation to at least said first strip and output means for receiving at least a portion of said optical radiation from at least said second strip.

23. A device according to claim 22, wherein the first and second strips are not coplanar.

24. A device according to claim 22 or 23, further comprising means for adjusting the characteristics of at least one of the first and second waveguide structures and thereby propagation characteristics of said plasmon-polariton wave propagating along the coupled strips so as to control the degree of coupling between the strips.

25. A device according to claim 22 or 23, wherein the material between the coupled strips is electro-optic and further comprising adjusting means for establishing an electric field in said electro-optic material and varying said electric field so as to vary the refractive index of the electro-optic material between the strips.

26. A device according to claim 25, wherein the adjusting means comprises a voltage source connected to the coupled strips for applying a voltage between the strips so as to establish said electric field in the said electro-optic material.

27. A device according to claim 25, wherein the adjusting means comprises at least one electrode adjacent at least one of the coupled strips and a voltage source for applying a voltage between the electrode and at least one of the coupled strips so as to establish said electric field in said material therebetween.

28. A device according to claim 22 or 23, wherein the material surrounding at least one of the coupled strips is electro-optic and the adjusting means comprises a pair of electrodes spaced apart with said at least one of the coupled strips between them and a voltage source connected to the electrodes for applying a voltage between the electrodes so as to establish an electric field in said electro-optic material, variation of said voltage causing a corresponding variation in the refractive index of said electro-optic material.

29. A device according to claim 22 or 23, wherein the material surrounding at least one of the strips is electro-optic, and the adjusting means comprises a pair of electrodes spaced apart with said at least one of the coupled strips therebetween and a voltage source connected between said at least one of the strip and both electrodes, in common, for applying a voltage between the electrodes and said at least one of the strips to establish an electric field in said electro-optic material, variation of said voltage causing a corresponding variation in the reflective index of said electro-optic material.

30. A device according to any one of claims 22 to 29, wherein the input means and the output means each comprise a pair of waveguide structures similar in construction to the first waveguide structure, and each pair comprises a pair of strips connected at one end to the respective ends of the coupled strips and diverging away therefrom so that distal ends of each pair of strips are spaced apart by a distance significantly greater than the spacing between the coupled strips.

31. A device according to claim 30, wherein each of said diverging strips comprises an S-bend.

32. A device according to claim 1, wherein the surrounding material is inhomogeneous.

33. A device according to claim 32, wherein the surrounding material comprises a continuously variable material composition or a combination of slabs and/or strips and/or laminae.

34. A device according to claim 1, wherein said relatively low free charge carrier density is substantially negligible.

35. A device according to claim 32, wherein the surrounding material comprises a single material or a combination of materials selected from the group consisting of glasses, electro-optic crystals, electro-optic polymers, and undoped or very lightly doped semiconductors, and preferably selected from the group consisting of silicon dioxide, silicon nitride, silicon oxynitride, quartz, lithium niobate, lead lanthanum zirconium titanate (PLZT), gallium arsenide, indium phosphide and silicon.

36. A device according to claim 1 or 32, wherein the strip is inhomogeneous.

37. A device according to claim 36, wherein the strip material comprises a single material or a combination of materials selected from the group consisting of metals, semi-metals, and highly n- or p-doped semiconductors, preferred materials being selected from the group consisting of gold, silver, copper, aluminium, platinum, palladium, titanium, nickel, molybdenum and chromium, metal silicides and highly n- or p-doped gallium arsenide (GaAs), indium phosphide (InP) or silicon (Si), and preferably from the subgroup consisting of gold (Au), silver (Ag), copper (Cu), and aluminium (Al), metal silicides such as cobalt disilicide ($CoSi_2$), and materials which behave like metals, such as Indium Tin Oxide (ITO).

38. An optical device according to claim 37, wherein the strip comprises layers of different ones of said materials.

39. A device according to claim 38, wherein the strip comprises a layer of gold and a layer of titanium and is surrounded by silicon dioxide.

40. A device according to claim 37, wherein the strip comprises gold and is surrounded by silicon dioxide.

41. A device according to claim 37, wherein the strip comprises gold and is surrounded by lithium niobate.

42. A device according to claim 37 wherein the strip comprises gold and is surrounded by PLZT.

43. A device according to claim 37, wherein the strip comprises gold and is surrounded by polymer.

44. A device according to claim 37, wherein the strip comprises aluminium and is surrounded by silicon.

45. A device according to claim 37, wherein the strip comprises cobalt disilicide and is surrounded by silicon.

46. A device according to claim 1, wherein the width is in the range from about 0.1 microns to about 12 microns and the thickness is in the range from about 5 nm to about 100 nm.

47. A device according to claim 46, wherein the surrounding material comprises silicon dioxide, silicon oxynitride, silicon nitride or other material having a refractive index in the range from about 1.4 to about 2.0, the width of the strip is in the range from about 0.5 μm to about 12 μm and the thickness of the strip is in the range from about 5 nm to about 50 nm.

48. A device according to claim 47, wherein the width of the strip is in the range from about 0.7 μm to about 8 μm and the thickness of the strip is in the range from about 15 nm to about 25 nm, the device supporting propagation of a plasmon-polariton wave having a wavelength in the range from about 1.3 μm to about 1.7 μm.

49. A device according to claim 48, wherein the width is about 4 μm and the thickness is about 20 nm, the device supporting propagation of a plasmon-polariton wave having a wavelength near 1.55 μm.

50. A device according to claim 46, wherein the surrounding material comprises lithium niobate, PLZT or other material having refractive index in the range from about 2 to about 2.5, the width of the strip being in the range from about 0.15 μm to about 6 μm and the thickness of the strip being in the range from about 5 nm to about 80 nm.

51. A device according to claim 50, wherein the width of the strip is in the range from about 0.4 μm to about 2 μm and the thickness of the strip is in the range from about 15 nm to about 40 nm, the device supporting propagation of a plasmon-polariton wave having a wavelength in the range from about 1.3 μm to about 1.7 μm.

52. A device according to claim 51, wherein the width of the strip is about 1 μm and the thickness of the strip is about 20 nm, the device supporting propagation of a plasmon-polariton wave having a wavelength near 1.55 μm.

53. A device according to claim 46, wherein the surrounding material comprises silicon, gallium arsenide, indium phosphide or other material having a refractive index in the range from about 2.5 to about 3.5, the width of the strip being in the range from about 0.1 μm to about 2 μm and the thickness of the strip being in the range from about 5 nm to about 30 nm.

54. A device according to claim 53, wherein the width of the strip is in the range from about 0.13 μm to about 0.5 μm and the thickness of the strip is in the range from about 10 nm to about 20 nm, the device supporting propagation of a plasmon-polariton wave having a wavelength in the range from about 1.3 μm to about 1.7 μm.

55. A device according to claim 54, wherein the width of the strip is about 0.25 μm and the thickness of the strip is about 15 nm, the device supporting propagation of a plasmon-polariton wave having a wavelength near 1.55 μm.

56. A device according to claim 2, wherein the strip is curved, its width is in the range from about 0.1 microns to about 12 microns, its thickness is in the range from about 5 nm to about 100 nm, and its radius of curvature is in the range from about 100 microns to about 10 cm.

57. A device according to claim 56, wherein the surrounding material comprises silicon dioxide, silicon oxynitride, silicon nitride, or other material having a refractive index in the range from about 1.4 to about 2.0, the width of the strip is in the range from about 0.5 μm to about 12 μm and the thickness of the strip is in the range from about 5 nm to about 50 nm, the strip being curved with a radius of curvature in the range from about 100 μm to about 10 cm.

58. A device according to claim 57, wherein the width of the strip is in the range from about 0.7 μm to about 8 μm, the thickness of the strip is in the range from about 15 nm to about 25 nm, and the radius of curvature is in the range from about 1 mm to about 10 cm, the device supporting propagation of a plasmon-polariton wave having a wavelength in the range from about 1.3 μm to about 1.7 μm.

59. A device according to claim 58, wherein the width is about 6 μm, the thickness is about 20 nm, and the radius of curvature is about 2 cm, the device supporting propagation of a plasmon-polariton wave having a wavelength near 1.55 μm.

60. A device according to claim 59, wherein the surrounding material comprises lithium niobate, PLZT, gallium arsenide, indium phosphide, silicon or other material having a refractive index in the range from about 2 to about 3.5, the width of the strip being in the range from about 0.15 μm to about 6 μm and the thickness of the strip being in the range from about 5 nm to about 80 nm, the strip being curved with a radius of curvature in the range from about 100 μm to about 10 cm.

61. A device according to claim 60, wherein the width of the strip is in the range from about 0.4 μm to about 2 μm, the thickness is in the range from about 15 nm to about 40 nm, and the radius of curvature is in the range from about 1 mm to about 10 cm, the device supporting propagation of a plasmon-polariton wave having a wavelength in the range from about 1.3 μm to about 1.7 μm.

62. A device according to claim 61, wherein the width of the strip is about 1.5 μm, the thickness of the strip is about 20 nm, and the radius of curvature of the strip is about 4 cm, the device supporting propagation of a plasmon-polariton wave having a wavelength near 1.55 μm.